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Demand Response Programs Implementation in North American Markets – Technical Features Comparison

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Abstract

The daily increment of the electricity demand in worldwide, obliges the electricity providers to hardly manage the relation between the generation and consumption. Therefore, the electricity operators should keep a gap between the total amount of generation and consumption in order to have not met the lack of energy generation, which leads to provide more energy resources. There is another solution to keep the gap between the amount of generation and consumption, which is defining such a program in specific periods for the demand side in order to reduce their consumption in response to the incentive paid by the electricity providers. This is defined as demand response program. These kinds of programs have been implemented worldwide, especially North America. Therefore, this paper provides a summarized report of the implemented DR programs on North American in 2015. More than 45 demand response programs have been surveyed and investigated. The main contribution of this paper is to compare the implemented DR programs parameters between 2013 and 2015. The results indicates that most of DR programs have kept the same values in the parameters, and there are several DR programs that they are not exist in 2013 and have been implemented in 2015.

Keywords: demand response, electricity retailer, service type.

1. Introduction

Nowadays, the use of Demand Response (DR) programs is widely surveyed. The DR programs are referred to the altering the consumption profile of the demand side, in order to response to the price variation and other technical or economic issues [1]. There are two major classifications for the DR programs: incentive-based and price-based [2, 3]. The incentive-based is related to the fixed or time varying incentive plans that is paid by the Retail Electricity Provider (REP). Price-based is referred to reforming of the end-users consumption curves for responding to the price variations [4]. Although, the DR programs can also be organized by the other parameters namely Service Type. These service types are: energy, capacity, regulation, and reserve [5], which can be defined as [6]:

- Energy: this service is based on the amount of delivered power by the demand resource in MWhs;
- Capacity: in this service type, it is mandatory for the demand resource to control the energy demand of the end-users for one or several pre-defined periods, which should be measured in MW;
- Regulation: this is a type of service that the demand resource decreases or increases the amount of consumption, depending on the real-time signals received from the REP or other system operator. These operators have to uninterruptedly transmit the DR data in the defined periods. Furthermore, the

parameters of this service type, such as deadlines, time periods, etc. are not considered in the DR event definition.

- Reserve: This service type is related to the demand resources that should be standby for the system operator in order to compensate the demand reduction.

The interesting point is that regulation and reserve services are two ancillary services, which are defined as support services in the power system and are essential in maintaining power quality, reliability and security [7].

Currently the DR programs has been implemented worldwide and they are transmitted to the customers in day-ahead of the DR event or very close to the event starting time (close to real-time). In the case of announcing the DR program in the event starting time, a ramp time will be considered for the customers in order to adapt the data and decrease the consumption till the desired value. Furthermore, the participation of the customers in the DR programs is completely voluntary and they indicate their availability in the DR programs. However, if they participate in the DR programs, there are several mandatory roles, namely total DR contribution limits, minimum resource size and reduction amount, etc. that should be considered by the customers.

The work presented in this paper is a summarized report of the implemented DR programs on North American Independent System Operator/ Regional transmission organization (ISO/RTO), called "North American Wholesale Electricity Demand Response Program Comparison" published in 2016 [8]. There are up to 48 DR programs presented in this paper and classified by the service types represented in above. The main focus is given to comparison between the present work, and the one presented in [5] regarding the same DR implementation report in North American but in the year of 2013. This paper also provides the all of the modifications in the DR parameters that have been occurred between 2013 and 2015.

After this introductory section, the classification of the DR programs based on service type is proposed in section 2. Then, Section 3 represents the DR programs based on primary drivers. Section 4 describes Telemetry and After-The-Fact-Metering, and finally, the conclusion of the work is indicated in section 5.

2. DR programs based on Service Type

As it was described in the previous section, the DR programs can be classified in four main type: energy, capacity, regulation, and reserve. In this part, four tables are presented according to these four service types. These four tables are represented on Table 1 to Table 4. Each table may include several rows indicated by green. The values signified by this color in the tables, are the new DR programs that currently have been implemented by the North American wholesale electricity markets. In all of these tables, "OP" and "AR" are respectively the abbreviation of "Operational Procedure" and "Automated Response". The definition of other parameters used in the tables are available in [5], and they are not mentioned in the present paper due to space constraints.

Table 1 is referred to energy service type DR programs. As you can see the programs are classified to economic and reliability. In addition to green rows, red rows indicate the DR programs that have been excluded and are not executed now. One of these ignored DR programs is a specific case, which its trigger logic was defied as $100/MWh, and the rest were price-triggered programs. The other DR programs (uncolored rows), are the programs that were implemented in 2013 and still they are executing.

As it can be seen in Table 1, there are several parameters with the value of "-". They mean "undefined" or non-applicable", and they are completely different with "0". Additionally, the value "0" have different meanings in different parameters. For example, in aggregation allowed and response required, the value "1" means "Yes" and value "0" means "No", however, in the ramp period, "0" means "0 minutes".

All of the new DR programs in the energy service type, are in economic primary driver and their trigger logic is based on the price. Also, more than 75% of the DR programs are implementing in this service type are economic. As a general overview of the Table 1, it represents that in new DR programs minimum resource size and minimum reduction are not equal, and in most of the time aggregation is allowed and response is required as well. Additionally, there is no limit for the DR contribution.

Table 1. Energy Service Type in 2015.

Primary Driver	Trigger Logic	Min. Resource Size (kW)	Minimum Reduction (kW)	Aggregation Allowed	Response Required	DR Contribution Limit (%)	Min. Sustained Response Period (m)	Max. Sustained Response Period (m)	Advance Notification (m)	Ramp Period (m)	Sustained Response (m)	Recovery Period (m)
Economic	$100/MWh	100	100	1	0	-	-	-	-	0	-	-
	price	100	100	1	1	-	-	-	1200	0	-	-
	price	100	100	1	1	-	-	-	1200	0	-	-
	op	100	100	1	0	-	-	-	120	30	-	-
	price	100	10	1	1	-	-	-	1200/0	-	60	-
		100	1	1	1	-	60	660	1200	-	-	-
		100	100	1	0	-	-	-	120	-	-	-
		100	100	1	1	-	-	-	-	5	5	-
		100	100	1	1	-	60	-	5	5	5	5
		1000	0	0/1	0	-	-	-	1200	5	60	-
		1000	100	1	1	-	240	240	150	-	240	-
		1000	100	0	1	-	5	-	5	5	60	-
		1000	100	1	1	-	5	-	5	5	60	-
		1000	1000	1	1	-	60	-	1200	-	-	-
Reliab.	OP	0	0	1	1	-	-	240	-	60	-	-
		100	0	1	0	-	-	-	-	-	-	-
		100	100	1	0/1	-	-	-	120	120/30	240/-	-

The second table (Table 2) is related to the capacity service, which is only classified by reliability primary driver. In contrary with the energy type and similar to the DR programs implemented in 2013, the most of the DR programs have economic trigger logic and in some cases, it is based on the peak consumption hours. As specified with green color in the Table 2, there are three new DR programs that have been implemented in 2015. Two of them are exactly repeated from a program which was implemented in 2013. It means there are three distinct programs, with same features and same event timing.

Table 2. Capacity Service Type in 2015.

Primary Driver	Trigger Logic	Min. Resource Size	Minimum Reduction	Aggregation Allowed	Response Required	DR Contribution Limit	Min. Sustained Response Period	Max. Sustained Response Period	Advance Notification	Ramp Period	Sustained Response	Recovery Period
Reliability	load >= 90% peak	100	1	1	1	-	-	-	-	0	-	-
	Peak hours / Price	100	1	1	1	-	-	-	-	0	-	-
	OP	0	0	1	1	-	-	-	-	7	480	-
		100	100	1	1	-	-	720	-	30/10	-	600
		100	1	1	1	-	-	-	30	30	-	-
		100	0	1	1	-	240	-	-	-	240	-
		100	100	1	1	-	-	360	120	30	-	-
		100	100	1	1	-	-	600	120	30	-	-
		100	100	1	1	-	-	600	120	30	-	-
		100	100	1	1	-	-	600	120	30	-	-
		100	100	1	1	-	-	-	120	30	-	-
		500	500	1	1	-	-	180	-	10	-	-

Also, it is obvious that in the capacity service type, the aggregation is always allowed and the response requirement is always mandatory as well. There is no limitation for contributing in DR programs that refers to the demand resources obligation described in introduction part.

Next table (Table 3) concerns about one of the ancillary services named regulation service. In this service type there is no new program and the DR programs that were implemented in the 2013, still are executing. Similar to the year of 2013, the ramp period is always equal to zero and vindicate this sentence that regulation service does not follow the time periods of DR event definition [5].

The last table of this section (Table 4) represents the DR programs categorized by the reserve service type. In this table, there is one new and one modified DR programs comparing with 2013. These two DR programs are colored by green in the Table 4.

Table 3. Regulation Service Type 2015.

Primary Driver	Trigger Logic	Min. Resource Size	Minimum Reduction	Aggregation Allowed	Response Required	DR Contribution Limit	Min. Sustained Response Period	Max. Sustained Response Period	Advance Notification	Ramp Period	Sustained Response	Recovery Period
Econ.	OP	100	100	1	1	-	60	-	5	0	-	-
	Price	1000	0	0	1	-	-	-	1200	0	60	-
		1000	1000	1	1	-	60	-	5	0	-	-
Reli.	AR	100	100	0	1	-	-	-	-	0	-	-
	OP	100	100	1	1	0,25	-	-	-	0	-	-
	Price	1000	100	1	1	-	-	-	1200	0	-	-

Table 4. Reserve Service Type 2015.

Primary Driver	Trigger Logic	Min. Resource Size	Minimum Reduction	Aggregation Allowed	Response Required	DR Contribution Limit	Min. Sustained Response Period	Max. Sustained Response Period	Advance Notification	Ramp Period	Sustained Response	Recovery Period
Economic	OP	100	100	1	0	-	60	-	5	10	60	-
	Price	500	10	1	1	-	-	-	1200	10	-	-
		1000	0	1	1	0,4	-	-	1200	10	60	-
		1000	1	1	1	-	-	-	-	-	-	-
		1000	1000	1	1	-	60	-	75	10/30	-	-
Reliability	Freq.	1000	1000	1	1	-	-	-	-	0	60	-
	OP	100	100	1	1	-	-	-	-	30	-	-
						0,33	-	30	0	10	-	-
						0,25	-	-	120	30	-	-
		5000	5000	1	1	-	-	-	-	10	60	-
		10000	10000	0	1	-	-	-	-	10	60	-
	OP+AR	100	100	0	1	-/0,5	-	-	-	10	-	-/180

The modified program is the first green row, which is economic-driven and is triggered by price. The only parameter that has been changed, is the DR contribution limit, which was 30% in 2013, and is 40 % in 2015. The new added program is the second green row, which is a reliability-driven program and has OP in the trigger logic. The minimum resource size has been significantly increased and reached to 10000 kW. This is equal for the minimum reduction amount, which is 10000 kW as well. However, the maximum of these two parameters in the entire implemented DR programs in 2013, were 5 MW. Furthermore, the aggregation is not allowed in this program, however, the response is required. The ramp period and sustained response are equal to the programs defined in 2013, which are respectively 10 and 60 minutes.

3. DR Programs based on Primary Driver

As it was shown in previous section, all the service types, except capacity, were classified by two features "economic" and "reliability" named as primary driver. In this part several charts have been demonstrated, which organized the DR programs according to primary driver. The analysis of DR programs by primary driver is presented in Figure 1 and in Figure 2, respectively for the DR program features and for the DR event timing. Figure 1 (a) and Figure 2 (a) are depicted the reliability results, while Figure 1 (b) and Figure 2 (b) illustrate the economic-driven programs. As it can be seen in all figures, the data has been normalized, i.e. all of the values have been scaled in 0-1. It was assumed that the top scale actual values are: 10000 kW

for minimum resource size and minimum reduction, 1200 minutes for the advance notification, 120 minutes for the ramp period, 480 minutes for the sustained response, and 600 minutes for the recovery.

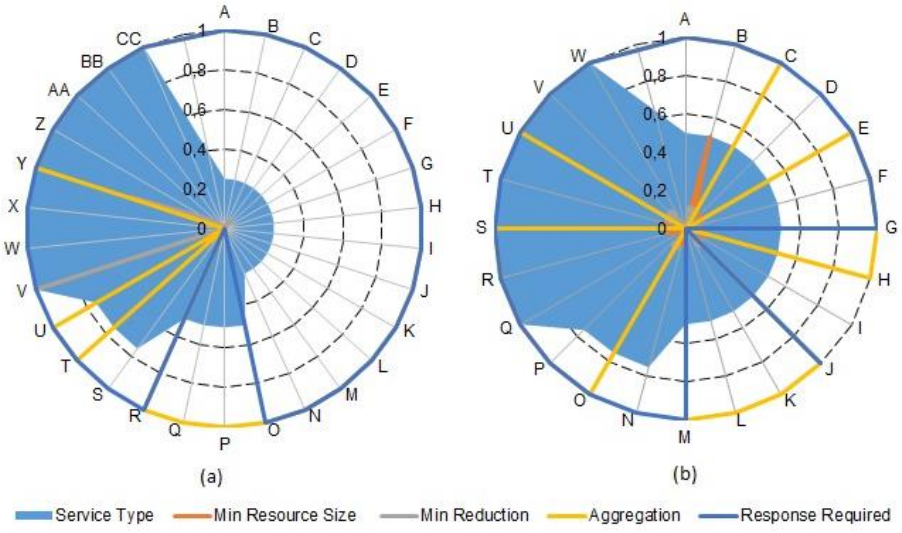

Fig. 1: DR programs classified by features; (a) Reliability, (b) Economic.

For better comparison between 2013 and 2015, the service types is the same in the both years: Capacity – 0,25; Energy – 0,5; regulation – 0,75; Reserve – 1. Additionally, it is clear that there is no modification in the service type sorting. In one of the DR programs, the minimum resource size and minimum reduction have been increased to 10000 kW. This leads that the smaller scales of the other DR programs parameters, will not be able to be demonstrated in the figures.

Concerning the aggregation permission, there are a few number of new DR programs that have more restrictions comparing with 2013. In addition, for the new DR Programs, the response is always required.

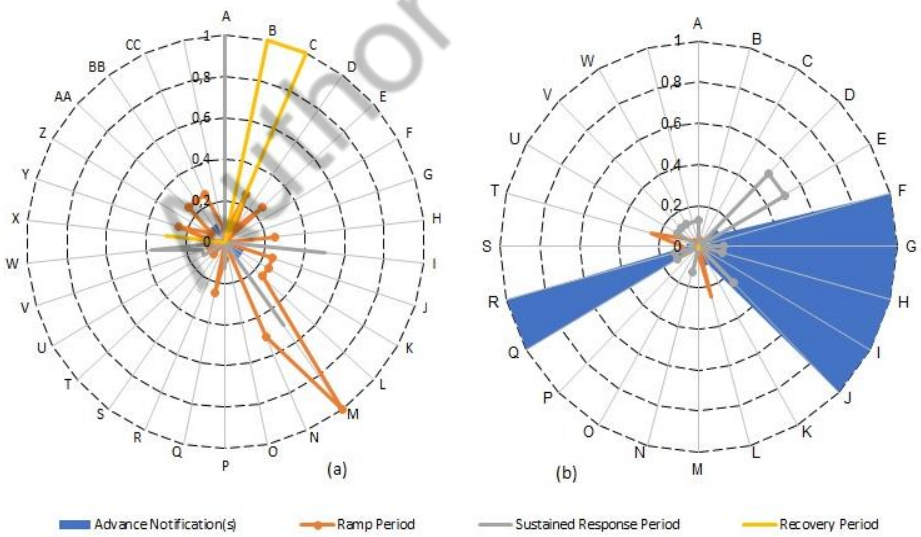

Fig. 2: DR event timing; (a) Reliability, (b) Economic.

As it mentioned in above, Figure 2 is correlated to DR event timing that divided by reliability and economic primary driver. According to the results obtained in 2013, in the economic-driven event timing programs there are more changes comparing with the reliability-driven programs. Furthermore, based on the obtained results in 2015, ramp period in reliability-driven is higher than economic-driven and this is in contrary of results acquired in 2013. Additionally, Figure 2 illustrates this fact that new DR programs implemented are more similar to previous programs in parameters such as minimum resource size, minimum reduction, aggregation and response required, comparing with the event timing. The Event timing in the new programs caused the variations between them.

4. Telemetry and After The Fact Metering

For each DR service, there is an efficiency analyze in order to dedicate the reduction of the specific demand resource. For this analyze, two fundamental methods is employed for the DR event, which are Telemetry and After The Fact Metering.

Telemetry is defined as a component to measure a quantity, and conveys the outputs to a remote place in order to manage, monitor, and store the data. After The Fact Metering is related to the measured data that are metered with a specific time interval. This method may not be utilized for the demand resources, which are below the Baseline Type II (Non-Interval Meter) [6]. Table 5 shows the comparison of four service types according to telemetry and after the fact metering [8].

Table 5. DR service types based on Telemetry and After The Fact Metering.

	Telemetry			**After The Fact Metering**		
Service Type	**Telemetry Requirement**	**Telemetry Reporting Interval**	**On Site Generation Telemetry Requirement**	**After-The-Fact-Metering Requirement**	**Meter Data Reporting Deadline**	**Meter Data Reporting Interval**
Energy	25%	2sec_5min	15%	100%	Max. 103 days	Max. 1 hour
Capacity	21.4 %	4sec_5min	21.4 %	100%	Max. 103 days	Max. 1 hour
Regulation	100%	2sec_6sec	50%	83%	Max. 55 days	Max. 1 hour
Reserve	73%	2sec_1min	40%	80%	Max. 55 days	Max. 1 hour

As it can be seen in Table 5, these two methods of DR programs measuring are essential for all service types that discussed before. However, telemetry is more utilized in the ancillary services (regulation and reserve). It is clear that telemetry reporting interval is up to 5 minutes. The parameter "On Site Generation Telemetry Requirement" is shown based on DR service types categories. Furthermore, After The Fact Metering is always required for energy and capacity services and in the most of the time is required for regulation and reserve services. Meter data reporting interval for energy and capacity services should not be more than 103 days after DR event, and for regulation and reserve service should not be more than 55 days after DR event as well. Additionally, the maximum time of data reporting interval for all of the service types are up to 1 hour.

5. Conclusions

The implementing and executing demand response programs is becoming a reality in the current power systems. The demand response program is cost effective for the both sides of the grid, the electricity customers by reducing their electricity bills and the grid operators by shifting the high consumption loads to the off-peak moments. Additionally, by implementing these types of programs, the grid congestions can be relived, which leads to decrease the requirements of peaking generation capacity. North American electricity markets are vanguard in the implementation of demand response programs.

In this paper, we presented a summarized report of the implemented demand response programs on North American electricity market in 2015. More than 45 programs have investigated and categorized based on different parameters of the demand response programs. Additionally, this paper provided a comparison between the implemented demand response programs on North American in 2013 and 2015. The modified and added programs have been illustrated and surveyed.

The results of this papers demonstrates that the utilization of demand response programs has been increased comparing with the past years, since they are several new programs that were not exist in 2013, and currently they are executing. Furthermore, there is several programs that their capacities has been enlarged, which proves the interest of electricity provides as well as the customers to employ demand response programs.

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